REMARKS

Regarding the Figures

Substitute figures are being submitted herewith in response to the requirement for new drawings.

Regarding the claim amendments

Claim 1 has been amended. Support for the limitation "in the form of a film" is found in original claim 4. Support for the limitation "from 0.02 to 30 atomic % is found in original claim 3. Support for the limitation "that extends in a thickness direction of the film" is found in original claim 4. Support for the newly added density limitation is found on page 5 line 12 of the English language specification.

Claim 2 has also been amended, support for the new limitation ("in the form of a film") being found in previous claim 9 and original claim 4.

Claims 5 and 6 have been amended to specify that the source of carbon atoms contains pieces of the metal element. This is supported at page 7 line 29 and page 8 lines 27-30 of the English language specification.

Conforming amendments are made to claims 8 and 10. Claims 3, 4 and 9 are canceled.

Concerning the rejections over Zabinski et al.

The applicants respectfully traverse the rejections based on Zabinski.

The invention defined in claim 1 is a hydrogen storage material in the form of a film. The film comprises distinct regions. The first region is a higher density region which includes an amorphous carbon and a specified amount of a metal element. The second region is a lower density region that is composed primarily of amorphous carbon. The second region has a specified geometry. The second region extends though the film in its thickness direction. In applicant's invention, the lower density "second region" takes the form of "fingers" that extend through the thickness of the film, as shown in applicants' figures 1 and 2.

Zabinski describes composite carbon/TiC films. Nothing in Zabinski suggests in any way that his composite films have separate, distinct regions of higher and lower density. Zabinski's discussion of densities (column 4) applies to his films as a whole; it does not state or suggest that his films have distinct regions of higher and lower density. Instead, that discussion simply points out that the overall density of Zabinski's film will depend on the ratio of titanium to carbon, and that those ratios can be through the sputtering process.

The examiner is also requested to take note of Zabinski's teaching that the DLC (diamond-like carbon) density is assumed to be 3.0 g/cm^3. This is higher than the density required of the low density region in applicants' claim 1. Therefore, Zabinski does not describe any film having a low density region in which the density is from 1.4 to 2.2 g/cm^3.

In addition, Zabinski's process is not identical to applicants' and for that reason it is not reasonable to infer that Zabinski's product is the same as applicants'. In particular, applicants' describe various process specifics, such as the use of a carbon target containing metal pieces, certain temperatures (p. 8, lines 2-11) and certain operating pressures (page 8 lines 12-24) which can provide the desired high and low density regions of the film. The last of these is particularly important, as Zabinski's operating pressures are all nearly an order of magnitude or more lower than the operating temperatures described by the applicants. The lowest operating pressure described in Zabinski is 2×10^{-3} torr, or about 0.266 Pa.

Since the operating conditions are not identical, it does not follow that Zabinski's products must inherently have the distinct low and high density regions specified by applicants' claims.

As to claim 2, Zabinski nowhere describes any film having voids, and therefore fails to anticipate or render obvious claim 2 or any claim depending from claim 2.

As to claim 5, Zabinski does not teach or suggest preparing a hydrogen storage material in a gas phase synthesis, using a carbon containing pieces of a metal element.

As to claim 6, Zabinski does not teach or suggest the operating pressure specified in that claim. On the significance of this limitation, the examiner's attention is drawn to the table bridging pages 11 and 12 of the specification. All materials tested there were made at a process pressure of about 2 Pa, except for Comparative Example 6, which was made at about 0.67 Pa process pressure. 0.67 Pa is about twice as much as Zabinski's highest pressure, and therefore is closer to the claim 6 invention than Zabinski. However, even when the operating pressure was about twice of Zabinski's value, the ability of the resulting

film to occlude hydrogen drops dramatically from those of working examples 1-4, which were made at about 2 Pa pressure. This demonstrates that the operating pressure during the film deposition process strongly affects the hydrogen storage properties of the film. This is nowhere suggested by Zabinski, who was not concerned at all with the hydrogen storage capacity of his films.

Regarding Iwamura

Applicants regard Iwamura as being even more removed from the present invention than Zabinski. In Iwamura, a low hardness film 4 is deposited atop a high hardness amorphous carbon film 5. The low hardness film 4 may contain Ti W, Si or Co. This multilayer structure is not at all similar to applicants' claim 1 film, which has low density regions permeating though higher density regions within a single film layer. Nothing in Iwamura teaches or suggests that his low hardness film 4 would contain regions of higher density and regions of lower density. Also, applicants maintain that the examiner is mistaken in correlating density with hardness. In Iwamura's example 1-14 at least, both his "high hardness" layer 4 and his "low hardness" film 5, appear to be simply carbon layers that are applied under different conditions (different dc substrate bias voltage per paragraph 0057). These carbon layers would be expected to have the same densities, since both of them are made up of carbon. Therefore, hardness does not correlate to density; instead it correlates to the applied dc substrate voltage during film formation.

As to claim 2 and claims depending therefrom, Iwamura does not disclose a film having voids.

As to claim 5, Iwamura does not teach or suggest preparing a hydrogen storage material in a gas phase synthesis, using a carbon containing pieces of a metal element.

As to claim 6, Iwamura does not teach or suggest the operating pressure specified in that claim. Iwamura's sputtering conditions are described in paragraph 0044. The highest pressure indicated there is 3 mtorr, which corresponds to about 0.4 Pa, which is well below the value recited in claim 6.

Regarding the rejections over Bauer et al.

In its most relevant portions, Bauer is similar to Zabinski and fails to anticipate or render applicants' invention obvious for the same reasons.

Bauer describes 4 types of films:

1. pure carbon films, non-graded (section 3.1)
2. carbon films with Ti-C addition, non-graded (section 3.2)
3. graded pure carbon films (section 4.1)
4. graded carbon films with Ti-C addition (section 4.2).

Only type 4 is at all relevant to applicants' invention.

By "graded", Bauer is not referring to films having a composition that varies though the film structure. Instead, Bauer is referring to a specific operating condition, substrate bias voltage, which is varied (i.e., "graded") during the sputtering process. Bauer found that film hardness can vary with applied substrate bias voltage, which is exactly the same as Iwamura teaches. Significantly, Bauer teaches that "grading" the film can increase hardness even if the film is pure carbon (section 4.1) (which is also what Iwamura teaches).

Therefore, Bauer does not teach or suggest any film having higher and low density regions as recited in applicant's claim 1. Bauer does not describe any films having voids as in applicants' claim 2, 7, 8 or 10. Furthermore, Bauer does not describe the process of applicants' claim 5 (Bauer uses a TiC target for his sputtering process) or of applicants' claim 6 (Bauer's pressures are less than 5 X 10^{-4} Pa, as mentioned in the right-hand column of page 1140).

Respectfully submitted,
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